Towards γ - Spectroscopy of ^{237f}Pu ◇

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While so far spectroscopic studies of fission isomers concentrated on even - even nuclei [1,2], high - resolution γ - spectroscopy of odd - N fission isomers will allow the identification of Nilsson orbitals in heavy, extremely deformed actinide nuclei for the first time [3]. In order to prepare for the investigation of ^{237f}Pu ($t_{1/2} = 110$ ns), following the ^{235}U(α,2n) reaction, the small population cross section (ca. 2 μb), requires a large solid angle coverage both for the γ - rays as well as for the fission fragments.

In order to realize a compact as well as cost-effective solution for the fission fragment detection, in a first series of preparatory experiments a 4π array of silicon solar cell detectors was developed and tested. This array proved to be very well suited for an efficient detection of fission fragments when used in thin-target experiments [4,5]. However, in the main experiment a thick metallic ^{235}U target is required in order to allow for an emission of γ rays from stopped fission isomers in the center of the MINIBALL γ spectrometer at the IKP, Cologne. The production (as well as the handling) of these highly oxidizing targets represents the key challenge of the experiment. Unfortunately presently no purely metallic ^{235}U isotopic material without any oxide contamination can be purchased worldwide. Thus sophisticated purification procedures had to be applied in the Garching Radioactive Technological Laboratory, however finally limiting the achievable target thickness after rolling under Argon atmosphere to 3.5 mg/cm^2. An elaborate load lock and transport system was used to guarantee an oxide-free transfer of the target from the glove box at Garching into the MINIBALL setup at Cologne. However it would have been advantageous to be able to use a target thickness of 1.5 - 1.7 mg/cm^2 as used in older experiments [2] in order to reduce the energy loss and straggling of the fission fragments crossing the target. As it turned out, after having lost on average 70 % of their kinetic energy, the fission fragments subsequently detected in the solar cell array could not be unambiguously separated from background originating from scattered projectiles. Thus the solar cell array had to be abandoned. Instead parallel plate detectors, although requiring more technical effort, have excellent detection properties for fission products. Presently the PPAC array already used in Heidelberg for the investigation of ^{240f}Pu [2] is refurbished and tested to be used in the next MINIBALL experimental campaign at the Cologne Tandem. Eight trapezoidal detector modules combined into an octaeder structure with a diameter of 8.5 cm will allow for a solid angle coverage of about 70% of 4π.

The PPAC is set up (see Fig. 1) with a segmented anode backplate to which a spacer carrying the cathode foil is glued, on this cathode foil a further spacer carrying the entrance window is positioned. The segmentation of the anode was adapted to the regions of equal time of flight of the fission products, defined by the detector orientation and the fragment velocity after the (angular dependent) energy loss and straggling in the thick target. Thus in each region individually optimized gating for the separation between prompt and delayed fission fragments will be enabled.

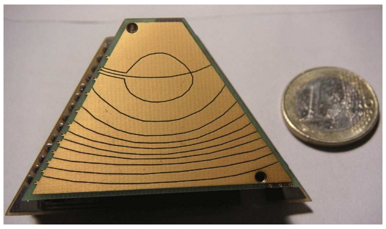

Fig. 1: Anode plate of the trapezoidal PPAC modules. The segments represent regions of equal time of flight for the fission fragments. Eight of these modules form the array shown in Fig. 2.

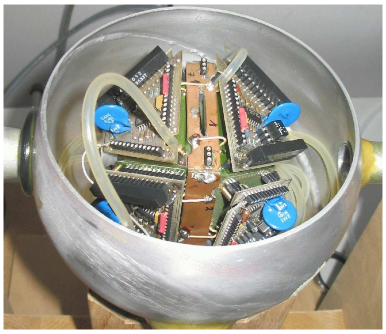

Fig. 2: 4π PPAC array mounted in the target chamber

The excellent time resolution, of the PPAC's (< 0.5 ns) will allow to distinguish between the dominant prompt fission products and the rare isomeric fission events ($t_{1/2} = 110$ ns). In November 2005 a MINIBALL campaign is scheduled in Cologne during which the PPAC array will be installed and spectroscopy of ^{237}Pu will commence. Using a target thickness of ≤ 3.5mg/cm^2, eigth triple Ge MINIBALL clusters ($\varepsilon_{ph} \sim 5.2$ %) and an average beam intensity of 1 nA will result in an expected average delayed fission yield of ~ 300 detected events per hour.

References

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